WHAT IS CLAIMED IS:

1. A bump forming method which comprises the steps of:

accumulating a soft solder alloy on the surface of a workpiece;

irradiating the accumulated soft solder alloy with at least plasma containing hydrogen; and

applying reflow treatment to the soft solder alloy that has been irradiated with at least said hydrogen-containing plasma, thereby forming solder bumps, which will serve as connecting terminals, on the surface of the workpiece.

2. A bump forming method as claimed in claim 1, wherein the hydrogen-containing plasma irradiation and the reflow treatment are performed in a vacuum.

3. A bump forming method as claimed in claim 1 , wherein the reflow treatment is performed in either an inert gas atmosphere or a reductive atmosphere.

4. A bump forming method as claimed in claim 1, wherein the irradiating with hydrogen-containing plasma is performed at a temperature lower than the melting point of the soft solder alloy.

5. A bump forming method as claimed in claim 1, wherein the process gas for generating the hydrogen-containing plasma is a mixed gas containing an inert gas and hydrogen gas that contains hydrogen with a mixing ratio of equal to or more than 3 V/V % but less than 8 V/V % calculated in terms of hydrogen molecules.

6. A bump forming method as claimed in claim 1, wherein the duration of the

plasma irradiation is limited to less than two minutes.

7. A bump forming method as claimed in claim 1, wherein the reflow treatment is conducted by means of heat radiation in a vacuum.

8. A bump forming method as claimed in claim 1 , wherein irradiation with fluorine-containing plasma is performed after the hydrogen-containing plasma irradiation.

9. A bump forming method as claimed in claim 8, wherein the fluorine-containing plasma contains either one of or both argon and oxygen.

10. A bump forming method as claimed in claim 8, wherein the duration and the temperature of irradiation with fluorine-containing plasma are respectively limited to within 60 seconds and a temperature lower than the melting point of the soft solder alloy, the range of permissible temperature including room temperature.

11. A bump forming method as claimed in claim 1, wherein the workpiece is preheated at a temperature not higher than 100 °C when conducting the reflow process.

12. A bump forming method as claimed in claim 1, wherein irradiation with hydrogen-containing plasma is performed again after the reflow process.

13. A soldering method which calls for bringing the soft solder alloy on the surface of a workpiece into contact with the surface of a bonding target, i.e. an object to which said workpiece is intended to be soldered, and thus bonding the surface of the workpiece to the surface of the bonding target by soldering during the reflow process of a bump forming method as claimed in claim 1 .

14. A solder bump forming apparatus adapted to use a soft solder alloy on the

surface of a workpiece to form solder bumps, which will serve as connecting terminals, said solder bump forming apparatus including:

a plasma generating means adapted to generate at least hydrogen-containing plasma under a low pressure;

a gas supply means for feeding process gas to the plasma generating means;

a workpiece exposing means for exposing the soft solder alloy on the surface of the workpiece at least to hydrogen-containing plasma; and

a heating means for applying a reflow treatment the soft solder alloy in a vacuum.

15. A bump forming apparatus as claimed in claim 14, wherein the plasma generating means is provided with:

a high frequency power supply and

an electrode connected to said high frequency power supply and adapted to generate plasma,

said electrode having:

a hollow electrode body adapted to receive the process gas;

supply openings that are adapted to feed the process gas and bored in the end of the electrode body facing away from the workpiece; and

through holes bored through the electrode body so as to extend from the end where the supply openings are formed to the opposite end.

16. A bump forming apparatus as claimed in claim 14, wherein the heating means is provided with:

a light source adapted to heat the backside of the workpiece by radiation, and

a reflecting mirror for adjusting luminous flux from the light source.

17. A bump forming apparatus as claimed in claim 14, wherein the apparatus includes a gas recovery means that defines the flow of the gas that carries plasma generated between said electrode and another electrode to the workpiece, said gas recovery means disposed such that the workpiece is positioned between the gas recovery means and the gas supply means.

18. A bump forming apparatus as claimed in claim 14, wherein the heating means includes:

a light source disposed at such a location so as not to be exposed to plasma and adapted to heat the workpiece by radiation, and

a reflecting mirror adapted to form an optical path extending from the light source to the workpiece.

19. A bump forming apparatus as claimed in claim 14, wherein the apparatus includes a gas supply means for supplying a process gas, which is a mixed gas containing an inert gas and hydrogen gas that contains hydrogen with a mixing ratio of equal to or more than 3 V/V % but less than 8 V/V % calculated in terms of hydrogen molecules.

20. A bump forming apparatus as claimed in claim 14, wherein the apparatus includes a high frequency power supply having a frequency of either 13.56 MHz or

2.45 GHz.

21. A bump forming apparatus as claimed in claim 14, wherein the plasma generating means is adapted to generate fluorine-containing plasma in addition to the aforementioned hydrogen-containing plasma, said fluorine-containing plasma containing either one of or both argon and oxygen.

22. A soldering apparatus including:

a bump forming apparatus as claimed in claim 14;

a positioning means for aligning and bringing the soft solder alloy on the surface of a workpiece that has been exposed to plasma and the surface of a bonding target into contact with each other; and

a heating means for applying reflow treatment to the film of the soft solder alloy, thereby soldering the surface of the workpiece and the surface of the bonding target together.

23. A bump forming method for forming bumps, which will serve as connecting terminals, on the surface of a workpiece by following the procedure that comprises the steps of:

roughening the surface of a soft solder alloy accumulated on the surface of the workpiece;

applying the roughened surface of the soft solder alloy surface reforming treatment that calls for forming a layer containing fluorine on the surface of the soft solder alloy; and

performing reflow of the soft solder alloy that has undergone said surface reforming treatment.

24. A bump forming method as claimed in claim 23, wherein the surface roughening treatment is performed by using plasma excitation of an inert gas to which hydrogen has been added.

25. A bump forming method as claimed in claim 24, wherein the quantity of the hydrogen added ranges from equal to or more than 3 V/V % to less than 8 V/V %.

26. A bump forming method as claimed in claim 24, wherein argon is used as the inert gas.

27. A bump forming method as claimed in claim 23, wherein the surface reforming treatment is performed by using plasma excitation of a mixed gas which contains a fluorine compound or fluorine compounds, and to which either one of or both oxygen and argon are added.

28. A bump forming method as claimed in claim 27, wherein the fluorine compound consists of at least one of the compounds selected from among carbon fluoride compounds, sulfur hexafluoride and nitrogen trifluoride.

29. A presoldering treatment method which comprises the steps of:

roughening the surface of solder bumps of a soft solder alloy formed on the surface of a workpiece, and

forming a layer containing fluorine on the roughened surface of the solder bumps, thereby applying surface reforming treatment to the surface of the solder bumps.

30. A presoldering treatment method as claimed in claim 29, wherein the surface roughening treatment is performed by using plasma excitation of an inert gas to which hydrogen has been added.

31. A presoldering treatment method as claimed in claim 30, wherein the quantity of the hydrogen added ranges from equal to or more than 3 V/V % to less than 8 V/V %.

32. A presoldering treatment method as claimed in claim 30, wherein argon is used as the inert gas.

33. A presoldering treatment method as claimed in claim 29, wherein the surface reforming treatment is performed by using plasma excitation of a mixed gas which contains a fluorine compound or fluorine compounds, and to which either one of or both oxygen and argon are added.

34. A presoldering treatment method as claimed in claim 33, wherein the fluorine compound consists of at least one of the compounds selected from among carbon fluoride compounds, sulfur hexafluoride and nitrogen trifluoride.

35. A soldering method for bonding together a plurality of workpieces by soldering, said soldering method comprising the steps of:

roughening the surface of solder bumps of a soft solder alloy formed on one or more workpieces;

forming a layer containing fluorine on the roughened surface of the solder bumps, thereby applying surface reforming treatment to the surface of the solder bumps; and

bringing said one or more workpieces having the solder bumps that have undergone the surface roughening treatment and the surface reforming treatment into contact with other workpiece or workpieces and, in this state, performing reflow of these workpieces.

36. A soldering method as claimed in claim 35, wherein the surface roughening treatment is performed by using plasma excitation of an inert gas to which hydrogen has been added.

37. A soldering method as claimed in claim 36, wherein the quantity of the hydrogen added ranges from equal to or more than 3 V/V % to less than 8 V/V %.

38. A soldering method as claimed in claim 36, wherein argon is used as the inert gas.

39. A soldering method as claimed in claim 35, wherein the surface reforming treatment is performed by using plasma excitation of a mixed gas which contains a fluorine compound or fluorine compounds, and to which either one of or both oxygen and argon are added.

40. A soldering method as claimed in claim 39, wherein the fluorine compound consists of at least one of the compounds selected from among carbon fluoride compounds, sulfur hexafluoride and nitrogen trifluoride.

41. A bump forming apparatus including:

a surface roughening device for roughening the surface of a soft solder alloy accumulated on a workpiece;

a surface reforming device for performing surface reforming treatment by

forming a fluorine containing layer on the roughened surface of the soft solder alloy; and

a thermal melting unit for performing reflow of the soft solder alloy having the reformed surface, thereby forming solder bumps, which will serve as connecting terminals, on the surface of said workpiece.

42. A bump forming apparatus as claimed in claim 41, wherein:

the surface roughening device is a plasma exciting device adapted to roughen the surface of a soft solder alloy by means of plasma excitation, and

the plasma exciting device and the surface reforming device are respectively operated in separate and different atmospheres without a pause between operation of the plasma exciting device and the operation of the surface reforming device.

43. A presoldering treatment apparatus including:

a surface roughening device for roughening the surface of solder bumps of a soft solder alloy formed on a workpiece, and

a surface reforming device for performing surface reforming treatment by forming a fluorine containing layer on the roughened surface of the solder bumps.

44. A presoldering treatment apparatus as claimed in claim 43, wherein:

the surface roughening device is a plasma exciting device adapted to roughen the surface of a soft solder alloy by means of plasma excitation, and

the plasma exciting device and the surface reforming device are respectively operated in separate and different atmospheres without a pause between operation of

the plasma exciting device and the operation of the surface reforming device.

45. A presoldering treatment apparatus as claimed in claim 43, wherein the surface roughening device is adapted to roughen the surface of the solder bumps of the soft solder alloy in a mechanical way.

46. A soldering apparatus which is adapted to solder together a plurality of workpieces and includes:

a surface roughening device for roughening the surface of solder bumps of a soft solder alloy formed on one or more workpieces;

a surface reforming device for performing surface reforming treatment by forming a fluorine containing layer on the roughened surface of the solder bumps; and

a thermal melting unit for bringing one or more workpieces having the solder bumps that have undergone the surface roughening treatment and the surface reforming treatment into contact with other workpiece or workpieces and, in this state, performing reflow of these workpieces.

47. A soldering apparatus as claimed in claim 46, wherein:

the surface roughening device is a plasma exciting device adapted to roughen the surface of a soft solder alloy by means of plasma excitation, and

the plasma exciting device and the surface reforming device are respectively operated in separate and different atmospheres without a pause between operation of the plasma exciting device and the operation of the surface reforming device.

48. A soldering apparatus as claimed in claim 46, wherein the surface roughening

device is adapted to mechanically roughen the surface of the solder bumps of the soft solder alloy.

49. A presoldering treatment method as claimed in claim 29, wherein the roughening step further comprising the step of:

mechanically roughening the surface of solder bumps formed on a solder bump plate by means of a roughening member comprising:

a bumpy surface comprising minute indentations and protrusions disposed on the bumpy surface.

50. A presoldering treatment method as claimed in claim 49, further comprising the step of:

rolling a roller having a bumpy surface including minute indentations and protrusions disposed on the bumpy surface, which contacts the surface of the solder bumps during movement; the movement includes moving at least one of said roller against the solder bumps and moving the solder bumps against the roller simultaneously flattening and roughening, the surface of the solder bumps by contacting the roller.

51. A presoldering treatment method as claimed in claim 49, further comprising the steps of:

placing a flat plate, having a bumpy surface including minute indentations and protrusions disposed on the bumpy surface, which contact the surface of the solder bumps so the bumpy surface rests on the solder bumps

applying a given load to the flat plate so that the surface of the solder bumps is simultaneously flattened and roughened by the flat plate.

52. A presoldering treatment method as claimed in claim 49, further comprising the step of:

placing the solder bump plate on a flat plate having a bumpy surface including minute indentations and protrusions on the bumpy disposed surface, so solder bumps formed on said solder bump plate rest on the bumpy surface of the flat plate,

applying a given load to the solder bump plate so that the surface of the solder bumps is simultaneously flattened and roughened by the flat plate.

53. A presoldering treatment method as claimed in claim 52, further comprising the step of:

scratching, rubbing, or scrubbing the solder bump plate while applying a given load to the solder bump plate.

54. A presoldering treatment method as claimed in claim 49, wherein the surface roughening treatment further comprising the step of:

repeating a plurality of roughening actions to the surface of the same solder bumps.